Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20054

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In the Matter of	)	
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Implementation of	)	GN Dockets No. 09-47, 09-51, 09-137
Smart Grid Technology	)	
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Comments—NBP Public Notice #2
Tropos Networks Inc.

Tropos Networks Inc. ("Tropos") is pleased to submit these comments to the Federal Communications Commission (FCC) regarding the implementation of smart grid technologies.

Introduction and Background on Tropos Networks

Tropos is a venture backed private company based in Sunnyvale, California, and was founded in 2000. In the nine years since Tropos was founded, the company has developed IP wireless meshing technologies and systems that provide its customers with a foundation for deploying applications and services. During that period, Tropos has been granted 21 patents (40 more pending) and has taken a leadership position in the outdoor wireless broadband market with more than 750 customers around the world in a wide variety of industries including municipal government, utilities, and Internet service providers. Tropos' hardware and software systems have successfully helped its customers create greener, safer, smarter communities, and are helping utilities create the foundation for building an intelligent electrical grid.

Suitability of Communication Technologies for the Smart Grid

The central idea behind the smart grid vision is that information technology can revolutionize the delivery of electricity just as it has transformed other aspects of business. It is an ambitious but attainable vision that comprises distributed intelligence, automated control systems and broadband communications – building on commercially-proven technologies that exist today. Three of the key broadband network attributes required for successfully deploying smart grid applications are 1) throughput and latency, 2) broad coverage, and 3) security. Tropos provides the following data points from some of its deployments to address questions raised by the FCC about the ability of private wireless networks, specifically IP broadband mesh networks, to meet the demands of smart grid communications.

Throughput and Latency:

Distribution automation applications require response times from a few seconds to a few milliseconds, depending on the specific application and location within the distribution network. However, distribution system engineers have expressed a desire for networking that supports sub-cycle latencies to allow transmission and substation automation capabilities to be extended into the distribution plant in the future. Advanced sensors that generate larger volumes of data require real-time, high-speed communications links back to control centers. Utility field workforces employing bandwidth-intensive productivity applications such as mobile GIS need a communications network that provides high capacity two-way communications and supports seamless mobility for standards-based wireless devices. Real world low latency and high throughput is demonstrated in the following metrics from a broadband mesh network deployment in an Oklahoma municipal utility-owned network.

- 97 percent of the 426 broadband mesh nodes have round-trip latency < 20ms
- 81 percent of broadband mesh nodes have round-trip latency < 10ms
- Mean broadband mesh throughput: 6.8 Mbps / 6.4 Mbps (down/up)
- 95 percent of the 426 broadband mesh nodes have downstream throughput > 2 Mbps
- 92 percent of broadband mesh nodes have upstream throughput > 2 Mbps
- Network delivers 500 GB/day of public access data as well as utility and city data

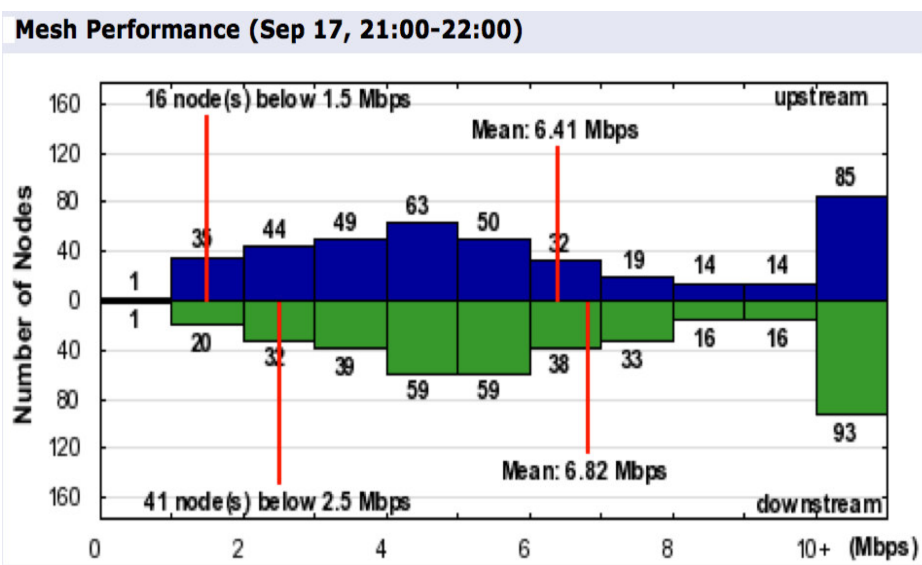

Figure 1: Histogram of mesh TCP throughputs

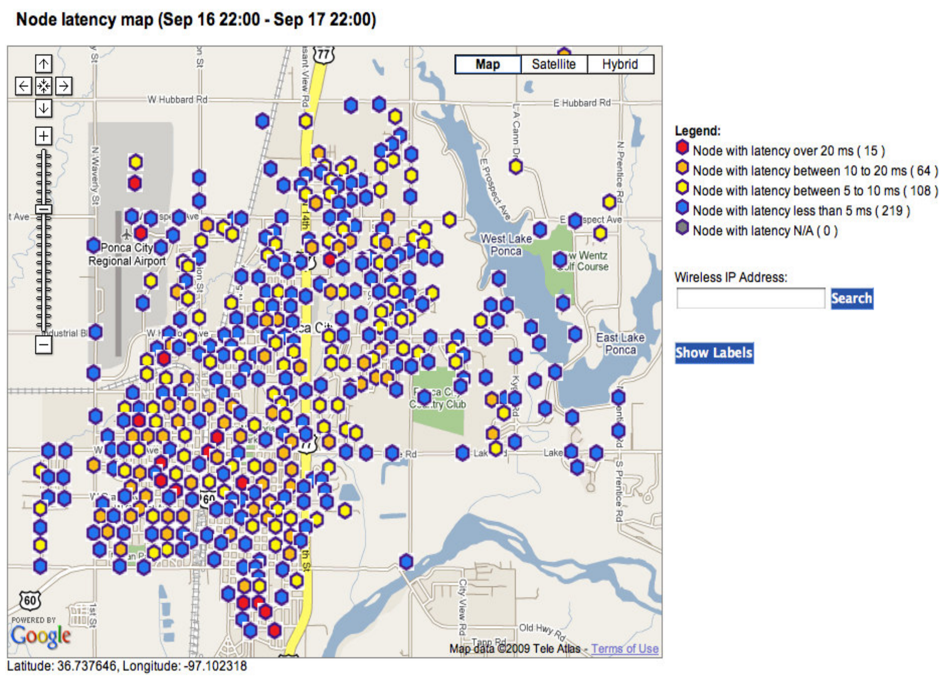

Figure 2: Distribution of mesh network round-trip latencies

Coverage:

A smart grid network infrastructure must provide broad coverage areas with broadband speeds to provide connectivity for applications. The following example from a broadband mesh network deployment in a Middle Eastern utility-owned network provides an example of a large coverage area and some of the applications deployed.

The network covers more than 5,000 square kilometers and comprises more than 3,000 mesh nodes servicing a wide range of utility applications, including water and electric AMR/AMI, street lighting control, mobile broadband for field workers, remote SCADA control and security monitoring for distribution and transmission assets. When the meter rollout is completed, there will be 1.4 million meters on the network, in addition to 750,000 street lights and 5,000 control cabinets as part of the street lighting control project. In addition, 2,100 utility vehicles and 7,200 field workers will have mobile access to the network. Video surveillance and monitoring also will be deployed to monitor critical facilities including substations.

Security:

Smart grid networks require high security that can protect sensitive data and prevent a loss of control to an unauthorized entity. The following metrics demonstrate a successful security implementation of a broadband mesh network deployment in a major mid-western city.

Initially a network exclusively for public safety, the 500+ square-mile network was designed to meet strict requirements on wireless access to state and federal databases. It has since been expanded to include multiple city agencies and more than 180 applications.

The implementation of security is based on open standards including 802.1x, 802.11i, AES, IPSec, FIPS 140-2, etc., utilizing a multi-layer security model that enables a secure multi-use framework to enforce data privacy, traffic segregation, and accommodate differing capabilities and requirements. The network has been in operation for more than four years and has experienced no security breaches.

Spectrum: Techniques for Mitigating Interference and Achieving High Reliability Over Unlicensed Spectrum

Mesh architectures are truly a step forward in technology. Similar advances have occurred in the past. Spread spectrum techniques and listen-before-talk protocols can be credited for making it possible for multiple Wi-Fi networks and Bluetooth devices to coexist in the same building, turning what was once considered a “junk band” into some of the most highly utilized spectrum in the world. Mesh networks take advantage of their orders-of-magnitude, more flexibility and distributed intelligence to route data around obstacles, running different hops along a path on different channels and at different modulations and power levels. Instead of a single choice -- a straight line between source and destination -- a mesh system has thousands of ways to bridge the distance, and can instantaneously switch among them as conditions change to maintain the most efficient and reliable links. Further, because they are able to seek out better, faster paths than the simple straight-line alternatives, mesh networks can squeeze far more capacity out of the same limited spectrum resources, enabling not only better reliability than broadcast systems, but support for more traffic.

Diversity Techniques

In distributed mesh system architectures, flexibility is maximized. Each wireless node in the network can intelligently select the frequency band and channel on which to operate each of its links based on its sensing of the local radio frequency (RF) environment, for example, rather than having fixed roles assigned to each of its radio interfaces. This flexibility translates directly into reliability, offering more ways to convey data, and more backup options to choose from as conditions change.

The mesh architecture provides path diversity. Any number of hops, in any direction can be taken to route around interference or equipment failures. The best path options are constantly evaluated so that routes can be changed in response to changes in the environment.

Multi-band routing provides frequency diversity. Within the enclosure of a single wireless node, two or more independent radios, complete with antennas, operate in separate bands, offering options with different propagation and penetration characteristics to complete each hop. Licensed and unlicensed radios can be teamed up, augmenting a narrowband system that is guaranteed to be free of interference with a wide swath of high-capacity unlicensed spectrum.

An advanced channel selection algorithm provides channel diversity. Background scans of all available channels are performed on an ongoing basis to maintain a complete history of noise levels and occupancy. Fast channel changes can be coordinated between nodes to eliminate interruptions.

Power and rate control provide coding diversity. These parameters are tuned on packet-by-packet, on a millisecond timescale, providing the system with its fastest way to react to changes in link quality and avoid data loss. The power-control algorithm considers the effects of each transmission on neighboring links, weighing individual link performance against overall network performance. The result is agile adaptation and a dramatic increase in system capacity.

An 802.11n-based array receiver provides spatial selectivity and noise cancellation. A technique called "Maximal Ratio Combining" is implemented as digital post-processing on multiple antenna inputs to focus in the direction of the signal of interest while canceling unwanted interference arriving from different directions. This is a powerful tool to gain reliability even in a very crowded radio environment.

Outdoor-Optimized Radios

Radios that are designed from the ground up to operate robustly in the presence of interference further enhance the reliability of an unlicensed broadband mesh solution. Transmit signals are high-powered and clean, with constant power levels across all channels. Multi-pole filters are used to lower side-lobes and enhance spectral purity so that no unintentional interference is created. Additional filters on the receive side cut away out-of-band signals, preventing them from saturating the receiver or impacting its sensitivity. A series of low-noise gain stages help achieve industry-leading sensitivity specifications and pick up exceedingly weak signals. Finally, an advanced Adaptive Noise Immunity algorithm dynamically tunes radio receiver parameters to optimize sensitivity even in noisy environments.

Successful interference mitigation in unlicensed spectrum

The following data points from a public access broadband mesh network in a Silicon Valley city in California demonstrate the ability to successfully mitigate interference in a challenging interference environment.

The city has a population of 70,000 and covers 12 square miles. Coverage is provided by approximately 500 mesh routers mounted on streetlights throughout the city. It is a harsh interference environment, requiring coexistence with an estimated 50,000 WiFi access points in the city (homes and businesses). In addition there are additional non-WiFi transmitters in the area, including an amateur TV ("Ham") station on edge of coverage area. There are also high-power out-of-band transmitters in the area that create interference to operation in the 2.4 GHz band, including an XM terrestrial repeater.

Though the majority of the routers in the network are based on a single-radio design (using only 2.4 GHz), the distributed auto-channel algorithm is able to find channels such that 90% of routers have at least 50% airtime available 99.8% have at least 40% airtime available. The measured system availability over a two year period is greater than 99.99% and network usage today stands at 600 GB/day and is growing rapidly.

Spectrum: Value of Additional Spectrum Allocation for the Smart Grid

The smart grid can be defined as the conjunction of distributed intelligence, broadband communications and advanced control systems. As such, smart grid systems need broadband capabilities and performance because the applications go beyond advanced metering to include bandwidth-intensive as well as latency-sensitive applications, including distribution automation, substation automation, power quality monitoring and mobile workforce applications such as GIS.

Utilities already are utilizing unlicensed spectrum for a number of these applications to good effect: many deployments in the planning or rollout stages have an unlicensed component. For example, 900 MHz unlicensed spectrum is commonly used for meter-to-meter communications; 2.4 GHz is used within home area networks; and combinations of 2.4 and 5.8 GHz unlicensed spectrum are used in wide-area networks. These unlicensed options have differing characteristics in terms of range and propagation characteristics, capacity and amount of available spectrum, and they will continue to play valuable roles in smart grid communication.

Conclusion

Allocation of additional spectrum for utility use for smart grid applications would be valuable, especially in light of the demands of smart grid applications. However, Tropos believes that use of such spectrum should not be mandated across the board because there is a broad range of applications and use cases where different spectrum options -- licensed as well as unlicensed -- can best be leveraged. For example, unlicensed 900 MHz (902-928 MHz), despite its limited system capacity, has propagation advantages at the meter level that would be hard to beat, even for a licensed 1.8 GHz solution. Different unlicensed options will continue to have valuable roles to play within the smart grid context. Utilities should be allowed the latitude to mix and match multiple solutions licensed and unlicensed to meet their specific application and deployment needs.

Sincerely,

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